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ABSTRACT

This study investigated the effects of organization at input and cued retrieval on the free- and cued-recall memory performance of children (all male and between the ages of 8 and 12) with and without attention deficit/hyperactivity disorder (ADHD). Children with ADHD (N=20) recalled significantly fewer words/pictures than children without ADHD (N=25) under free and cued recall, and under conditions of low and high organization at input. The two groups did not differ on a measure of clustering. Equivalent clustering scores for the two groups indicate that both groups of children used category membership at encoding and retrieval. Children without ADHD, however, were thought to be engaging in more active retrieval strategies than ADHD children. (Contains 24 references.) (PB)

Free and Cued Recall Memory Performance in Children With Attention Deficit-Hyperactivity Disorder

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Running Head: FREE AND CUED RECALL

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Abstract

The present study investigated the effects of organization at input and cued retrieval on the free- and cued-recall memory performance of children with and without ADHD. Children with ADHD recalled significantly fewer words/pictures than children without ADHD under free and cued recall, and under conditions of low and high organization at input. The two groups did not differ on a measure of clustering. Equivalent clustering scores for the two groups indicate that both groups of children are using category membership at encoding and retrieval, the children without ADHD, however, may be engaging in more active retrieval strategies than ADHD children.

Free and Cued Recall Memory Performance in Children with ADHD

Children with Attention Deficit-Hyperactivity Disorder (ADHD) do not perform as efficiently as non-ADHD (NADHD) children on memory tasks (Douglas, 1983). These differences are pronounced on memory tasks that require the spontaneous and active use of strategies (e.g., free recall tasks). Whereas, on tasks not requiring strategy use (e.g., serial recall tasks), children with ADHD can perform on a level comparable to that of NADHD children (Benezra & Douglas, 1988).

Several studies have investigated memory in children with ADHD. Memory studies using serial-recall tasks have failed to find differences between children with and without ADHD (Benezra & Douglas, 1988). Thus, children with ADHD appear to have efficient rehearsal strategies during simple, short-term memory tasks. Memory studies that have used free-recall procedures, however, often find significant differences in recall performance between children with and without ADHD (August, 1987; Borcherding et al., 1988; Voelker et al., 1989; Weingartner et al., 1980). These

differences can be reduced or eliminated when children are instructed to sort the items to be recalled into subjective categories (August, 1987; Hamlett et al., 1987) or when items are blocked upon initial presentation (Voelker et al., 1989). The two groups also exhibit comparable performance on recognition memory tasks (Borcherding et al., 1988).

Researchers also have examined strategy use in children with and without ADHD through the use of various clustering or strategy measures. August (1987) using the Adjusted Ratio of Clustering (ARC) (Roenker, Thompson, & Brown, 1971) found significantly higher clustering in his control group than in his ADHD group for a baseline trial. After an experimental/sorting trial, however, the children with ADD-H showed clustering scores comparable to that of the control group. This suggests that the children with ADHD began using a clustering when strategy when they were instructed to sort items into subjective categories. Weingartner et al. (1981) also found differences between a hyperactive and a normal control group for their measure of clustering. The control group was more likely to recall related words together than was

the hyperactive group. Hyperactive children in that study were more likely to cluster words related on the basis of sound rather than on the basis of meaning.

The major foci of studies investigating memory in children with ADHD have been on encoding and strategy usage at the encoding stage of processing. The study of retrieval mechanisms has been, for the most part, neglected in the ADHD memory literature. Only one published study has examined retrieval processes in children with ADHD (Weingartner et al., 1980).

Weingartner et al. (1980) conducted a study in which children with and without ADHD were presented 20 three-word lists. Words were presented in semantic- and acoustic-encoding conditions. The children were asked to choose from each list the word that was not like the other two words. All children were tested before and after amphetamine treatment. The two groups of children differed on free recall for a semantic-encoding condition but not for an acoustic-encoding condition. The administration of amphetamines enhanced free recall in both groups of children; however, children in the NADHD group exhibited higher free-recall scores than children with

ADHD. According to Weingartner et al. the administration of amphetamines enhanced the kind of processing that children were already using, but did not cause the children to engage in a different type of processing.

In the Weingartner et al. (1980) study, the two groups did not differ on a cued-recall task either before or after amphetamine treatment. Children in the ADHD group exhibited increases in recall similar to the NADHD children when cues were provided at retrieval. These findings suggest that children with ADHD may have learned more information than was detected using a free-recall paradigm. According to Weingartner et al., children with ADHD may form weaker memory traces or generate ineffective retrieval strategies.

In summary, children with ADHD frequently show poor memory performance when compared to their NADHD counterparts on free-recall tasks. Their poor performance is reflected by lower levels of recall and less clustering. However, children with and without ADHD show comparable recall performance when items are blocked upon initial presentation (Voelker et al., 1989), when children are allowed to sort the items to

be recalled into subjective categories (August, 1987; Hamlett et al., 1987), and when cues are provided at the time of retrieval (Weingartner et al., 1980). These findings suggest that children with ADHD may exhibit deficient performance on memory tasks with high encoding or retrieval demands.

The present study investigated memory performance in children with and without ADHD by examining both encoding and retrieval processes. Contextual cues should help to reduce deficits in recall by making previously inaccessible information accessible. The cued-recall paradigm is one way to examine the accessibility and availability of information in memory (Tulving & Pearlstone, 1966). This paradigm has many variations; however, the most important aspect of the paradigm is to hold encoding conditions constant for subjects while varying retrieval conditions. One variation of the paradigm is to present subjects with lists of words consisting of examples from different categories. One group of subjects is asked to recall as many words as possible without the aid of category name cues at retrieval. A second group is given the same encoding instructions but is supplied with

category name cues. The number of words recalled by the first group of subjects is taken as a measure of the accessibility of the information in memory; the number of words recalled by the second group of subjects, in the presence of cues, is taken as a measure of the availability of words in memory (Tulving & Pearlstone).

In a cued-recall condition, words that are available in memory, but are not accessible, become more accessible when cues are presented. Tulving and Pearlstone (1966) hypothesize that improved performance under cued-recall conditions indicates that the information has been stored but due to competition between items at retrieval, it cannot be freely recalled.

Practically all studies investigating memory in children with ADHD have focused on strategy use at the encoding stage of processing (August, 1987; Hamlett et al., 1987; Voelker et al., 1989). The results of Weingartner et al. (1980) and Borcherding et al. (1988), however, suggest that children with ADHD may have retrieval deficits as well as encoding deficits and that these deficits may be apparent on tasks with

high encoding and/or retrieval demands. To date, studies that have investigated memory in children with ADHD have not systematically examined both encoding and retrieval. When blocked information is presented, it aids in the encoding of information and provides a context at retrieval as well. Tulving and Pearlstone (1966) suggest that the "organization of material...seems to affect recall performance primarily by making the desired information more accessible in an otherwise limited biological retrieval system "(p. 390).

When memory problems exist, as they do for children with ADHD, it is important to investigate each stage of memory processing. The present study investigated both the interactive and independent effects of encoding and retrieval using both free- and cued-recall paradigms. The results of the present study were expected to support the hypotheses that children with ADHD suffer from retrieval deficits in addition to encoding deficits, and that retrieval deficits may play a large part in the poor memory performance of children with ADHD.

Instructions were provided that were intended to

influence the manner in which children would organize lists of information. Words and pictures were used as stimuli. Studies investigating memory performance in children with ADHD have used words as stimuli with the exception of the Hamlett et al. study which included both pictures and their word names. Tasks that have compared recall and recognition performance using words and pictures indicate that picture recall and recognition is usually superior to that of word recall and recognition (Durso & Johnson, 1979; 1980; Nelson, Reed, & Walling, 1976). The picture superiority effect is believed to be the result of pictures having more distinctive sensory codes than words, and the increased likelihood that pictures will undergo semantic processing relative to words.

Two measures were used to evaluate the free- and cued-recall performance of the children: the number of words/pictures recalled in each of the organization and retrieval conditions and the amount of clustering of words/pictures occurring at recall.

The following predictions were made: (1) Children without ADHD would recall more items than children with ADHD during free recall in the low-organization

condition; (2) Children in the high-organization condition would recall more items than children in the low organization condition; (3) Both groups of children would benefit from cues provided at retrieval with cued recall being higher than free recall; (4) Both groups would recall more pictures than words; (5) NADHD children would cluster more items than ADHD children in the low-organization condition; and (6) Children in the high-organization condition would cluster more items than children in the low organization condition.

Experiment 1

Method

Subjects. Forty-five male children between the ages of 8 and 12 participated in the study. The experimental group consisted of 20 boys (MCA = 10.9 yrs; SD = 1.2) recruited from a support group for parents of ADHD children or from the community through a newspaper advertisement. The inclusion criteria were: (a) primary diagnosis of ADHD by a psychiatrist, psychologist, or pediatrician; (b) T-scores of 65 or above on the hyperactivity subscale of the parent form of the Achenbach Child Behavior Checklist (CBCL) (Achenbach & Edelbrock, 1986); (c) report from the

parent that age at onset for ADHD was on or before age seven; and (d) a K-BIT IQ composite of 80 or above.

One of the boys included in the study had a concurrent diagnosis of learning disability. All children had abstained from taking stimulant medication at least 8 hours before the time of testing.

The control group consisted of 25 boys (MCA = 10.5 yrs; SD = .9) recruited from local elementary schools. In order for a child to be included in the NADHD group he must have met the following criteria: (a) three or fewer criteria for a diagnosis of ADHD on the SNAP Checklist (Pelham, Atkins, & Murphy, 1981); (b) T-scores of 60 or below on the hyperactivity subscale of the CBCL (Achenbach & Edelbrock, 1985); (c) a K-BIT IQ composite of 80 or above; and (d) no indication of a learning disability. Written consent was obtained from parents of the children in both groups. Parents and children were advised that participation from the study could be withdrawn at any time without penalty. Each child received a toy valued at approximately $4.00 for his participation in the study.

Behavioral and Psychometric Measures. The hyperactivity subscale of the CBCL (Achenbach &

Edelbrock, 1985) was used to help confirm a diagnosis of ADHD. Parents of the children in both groups were asked to complete the CBCL. The CBCL is considered to be a valid and reliable instrument for assessing hyperactive behavior in children (Sattler, 1988).

The updated version of the SNAP Checklist (Pelham, Atkins, & Murphy, 1981) using DSM-III-R criteria instead of DSM-III criteria also was used to help confirm a diagnosis of ADHD. The SNAP Checklist is not normed but includes all criteria for a diagnosis of ADHD. A symptom is considered to be present if the parent indicates that the symptom "pretty much" or "very much" describes his/her child. Parents of ADHD children were asked to indicate the age at onset for their son's disorder.

Intelligence classification was carried out for both groups using the Kaufmann Brief Intelligence Test (K-BIT) (Kaufmann & Kaufmann, 1990). The K-BIT was designed as a screening instrument for measuring intelligence. It is normed and has a test-retest reliability coefficient of .92 (IQ composite) for children ages 5 to 12. The K-BIT IQ composite demonstrates construct validity in that it correlates

with the Full Scale IQ of the Wechsler Intelligence Scale for Children-Revised (r=.80).

Achievement screening was carried out for both groups using the Woodcock-Johnson Tests of Achievement-Revised (Woodcock & Johnson, 1989). Reading and mathematics achievement were assessed.

In the present study, children demonstrating reading or mathematics achievement scores below 85 and 1.5 standard deviations below their IQ scores were considered learning disabled. These are considered to be the most stringent criteria for identifying learning disabilities (Barkley, 1990).

Duncan's socioeconomic index (SEI) was used to determine the socioeconomic status of the parents of both ADHD and NADHD children. This index was developed based upon the rankings of occupational status by members of the general population (Gottfried, 1985). Values of the index range from 0 (lowest status) to 98 (highest status).

Various behavioral, psychometric, and descriptive variables and statistical comparisons of the variables between groups are presented in Table 1.

Insert Table 1 about here

Apparatus and Testing Environment. The recall tests were programmed on a MacIntosh II computer using the Mindlab V2.1 software program (Bharucha & Baird, 1988). Each subject was seated approximately two feet in front of a 12" monochrome monitor. Testing took place in either the child's school or in the Psychology Department at the University of Alabama. Tests were administered by the principal investigator and an undergraduate assistant.

Materials. The stimuli for the Words condition consisted of 60 words grouped into 12 categories, as well as 16 words grouped into 4 categories for the practice test. The main test consisted of 3 word lists with 20 words in each list. Each list consisted of 4 categories with 5 words in each category. Category items for the practice list were taken from the adult category norms compiled by Battig and Montague (1969). Category items for the three lists of the main test were taken from the children's norms compiled by Posnansky (1978). Words were randomly chosen so that each category used in the study

consisted of words differing in their level of category representativeness. This procedure was followed to reduce the number of guesses made by children at the time of recall.

The same procedure was used for stimuli in the Pictures condition. Pictures were of items belonging to the same categories as those used in the Words condition. The items themselves, however, were different. Stimuli were presented in the middle of a computer screen for 2.5 seconds. All stimuli were presented successively with no delay occurring between stimulus presentations.

Procedure for Free and Cued Recall of Words. Each subject was tested individually. The order in which children received the two stimulus types (words and pictures) was counterbalanced. Children were randomly assigned to either the low- or the high-organization condition. Children were in the same organization condition for both the Words and Pictures conditions. Thirteen NADHD and 10 ADHD children participated in the low-organization condition. In this condition, categorically-related items were presented in a random fashion so that no two items from the same category

appeared successively. Children were told to name the items aloud to the tester and were instructed that they would be asked to remember the items in any order they wished at the end of the list.

Twelve NADHD and 10 ADHD children participated in the high-organization condition. In this cordition, categorically related items were presented in a blocked fashion so that all items from a category occurred successively before the next category of items was presented. Children were told that certain items on the list went together and were given the four category membership names represented in the list.

At the end of each list, children were asked to count backwards by threes from a randomly selected three-digit number for 30 seconds. This was done to prevent the children from rehearsing the material. Children were then asked to remember as many items as possible, in any order they wished. The tester recorded the order in which the children remembered the items, as well as any errors occurring during the learning and test phases of the lists.

Children were instructed to freely recall items at the end of the practice list and at the end of each of

the three lists of the main test. Children were given as much time as necessary for free recall. When the child had made no additional responses after a one- to two-minute period and had indicated that they were finished, the experimenter continued with the next list or with the cued-recall portion of the task. A cued-recall test was given following the free-recall period for the third experimental list. Children were provided category labels for the items appearing in the last list and were instructed to recall any additional items from the third list. Children were given as much time as necessary for cued recall. Again, if the child had made no response after a one- to two-minute period and had indicted that they were finished, the experimenter stopped the session.

Results

Two separate 2 (Group) x 2 (Stimulus Condition) x 2 (Organization) ANOVAs with repeated measures on the second factor were conducted on subjects' free-recall performance. The dependent measures were the number of items freely recalled from each of the three lists of 20 items and a measure of recall organization referred to as the Modified Ratio of Repetition (MRR) (Bower,

Lesgold, & Tieman, 1969). The MRR is an empirical measure of the organization imposed on stimuli in a free-recall situation. It has the advantages of being independent of the number of items recalled, and of allowing for comparison of different variables that affect clustering (Folarin, 1983). Perfect clustering is set at one and chance clustering is set at zero. The MRR score is the proportion of the actual category repetitions to the total number of items recalled minus the number of categories represented in recall.

Analyses were initially conducted using lists as a repeated-measures factor. The analyses indicated that there were no systematic effects on the two dependent variables as a function of the order of item lists, therefore recall was collapsed across list.

The NADHD children had significantly higher IQ scores than the ADHD children (Refer to Table 1). Correlations indicated that IQ scores were not significantly correlated with recall scores ($p<.05$), therefore, IQ was not entered as a covariate into the analyses.

Number of Items Recalled. The first ANOVA was conducted on the average number of items recalled on

the three lists. The ANOVA revealed a statistically significant difference in group performance for number of items freely recalled, $F(1, 41) = 15.69$, $p<.001$, indicating that the NADHD group ($M=7.5$) recalled significantly more items than the ADHD group ($M=5.5$) (See Figure 1). There was a main effect for organization, $F(1, 41) = 16.60$, $p<.001$, indicating that both groups recalled more items in the High-Organization Condition ($M=7.5$) than in the Low-Organization Condition ($M=5.5$). There was also a significant main effect for Stimulus Condition, $F(1,41) = 32.66$, $p<.001$. Both groups of children recalled significantly more pictures ($M=7.3$) than words ($M=5.8$). There was a significant Stimulus Condition x Organization interaction, $F(1,41) = 13.21$, $p<.001$. High organization was more beneficial to the children during the Words Condition than during the Pictures Condition.

Insert Figure 1 about here

Clustering Index. The analysis conducted on the

clustering index (MRR) revealed a main effect for organization, $F(1, 41) = 30.37$, $p<.001$ (See Figure 2), indicating that both groups clustered more in the High-Organization Condition ($M=.85$) than they did in the Low-Organization Condition ($M=.59$). There was a main effect for Stimulus Condition, $F(1,41) = 8.04$, $p<.01$; both groups clustered more in the Pictures Condition ($M=.76$) than in the Words Condition ($M=.67$). There was also a significant Stimulus Condition x Group interaction, $F(1,41) = 5.34$, $p<.05$. Children in the ADHD group ($M=.81$) clustered more than NADHD children ($M=.72$) in the Pictures Condition and NADHD children ($M=.70$) clustered more than ADHD children ($M=.63$) in the Words Condition. None of these differences were significant, however.

Insert Figure 2 about here

Correlations Between Free Recall and Clustering.

Separate correlational analyses were performed on the recall and clustering data for each of the organization and stimulus conditions. Significant correlations between clustering and recall are accepted as evidence

that strategy use has had a causal effect on levels of recall (Bjorklund & Jacobs, 1985). Table 2 shows the correlations between clustering and recall for both ADHD and NADHD children.

Insert Table 2 about here

Free versus Cued Recall. An analysis of subjects' recall of items in the two retrieval conditions of list three was conducted. The measure of cued recall consisted of the number of items recalled freely in addition to the number of items recalled with cues (See Figure 1). The data were analyzed using a four-way ANOVA (Group x Organization x Stimulus x Retrieval) with repeated measures on the last two variables. The analysis revealed a main effect for group, $F(1, 41) = 14.51$, $p<.001$. Children in the NADHD group ($M=9.1$) recalled significantly more items than children in the ADHD group ($M=7.1$). There were also main effects for Organization, $F(1, 41) = 18.90$, $p<.001$, Retrieval Condition, $F(1, 82) = 132.24$, $p <.001$, and for Stimulus Condition, $F(1,82) = 125.72$, $p<.001$. High organization ($M=9.3$) led to greater recall than low organization

(M=7.0), cued-recall performance (M=9.9) was better than free-recall performance (M=6.5), and recall for pictures (M=9.8) was greater than recall for words (M=6.7). The main effect for Organization was qualified, however, by a significant Stimulus Condition x Organization interaction, $F(1,41) = 8.91$, $p<.01$; with both groups recalling more words in the high-organization condition than in the low-organization condition. There were no significant effects for Organization for recall in the Pictures Condition.

Discussion

The task manipulations for encoding and retrieval yielded significant results. As predicted, children in the high-organization condition recalled more items than children in the low-organization condition. The effects of this manipulation are apparent in Figures 1 and 2. Both groups of children benefit from the organization of the materials with the exception of the ADHD children in the Pictures condition. It is unclear why the ADHD children in the high-organization condition failed to show higher levels of recall than ADHD children in the low-organization condition. According to Nelson et al. (1976), pictures are

believed to be more likely to undergo semantic processing leading to a picture superiority effect. Perhaps semantic processing is more effortful for ADHD children than for NADHD children. This may mean that there are fewer resources left for the storage of information. Indeed, the ADHD children in the high-organization condition fail to show higher levels of cued recall for pictures than ADHD children in the low-organization condition. This may indicate that similar amounts of information were stored by both the low- and high-organization ADHD groups. Thus, similar amounts of capacity may have been required for the low- and high-organization conditions for ADHD children.

Children in the high-organization condition also exhibited higher levels of clustering than children in the low-organization condition, as predicted. Thus, when organization of the items was imposed by the experimenter, both groups of children show increased clustering scores. This indicates that both groups were using clustering strategies.

The retrieval manipulation was successful in producing significantly higher recall when cues were provided for both ADHD and NADHD children. The picture

superiority effect (Durso & Johnson, 1979; 1980; Nelson et al., 1976) also was obtained with ADHD and NADHD children recalling significantly more pictures than words.

Differences Between ADHD and NADHD Children

The purpose of the experiment reported here was to determine whether the poor memory performance of ADHD children can be attributed to deficits in encoding or retrieval processes. The failure to find Group x Organization or Group x Retrieval interactions does not support the position that encoding and/or retrieval deficits contribute to ADHD children's poor memory performance.

In the present study, NADHD children recalled more words and pictures than ADHD children in both the low- and high-organization conditions. This finding differs from the findings of other studies in which items blocked at the time of presentation result in comparable levels of recall for ADHD and NADHD children (August, 1987; Hamlett et al., 1987; Voelker et al., 1987). There were, however, some important methodological differences between previous studies and the present study. In both the August and Hamlett et

al. studies, the children were instructed to organize the items at presentation, whereas, in the present study the experimenter provided the organization of the items at presentation. Also, in the Voelker et al. study, children were given a test to assess how much they knew about strategy use before being presented with tests of recall. This may have made the children more sensitive to the use of strategies during the related-item conditions. Studies designed to compare experimenter- versus subject-induced organization of items may provide some insight regarding the types of strategies used by ADHD children.

There were no overall differences between the groups for the clustering measure. Although in the Pictures condition, ADHD children in the low-organization condition did exhibit significantly higher clustering than NADHD children in the low-organization condition. In the Words condition, NADHD children in the high-organization condition exhibited significantly higher clustering than ADHD children in the high-organization condition. The failure to find clustering differences between the two groups is contrary to the findings of previous researchers (August, 1987;

Weingartner et al., 1981).

The paradigm used by Weingartner was a paired associate task and the clustering measure is not comparable to that used in the present study. The clustering measure used by August, however, is very similar to that used here. August used weakly categorizable nouns, whereas, the stimuli used in the present study were all items belonging to one of four semantic categories. ADHD children may have been more likely to use a clustering strategy in the present study because of the relatedness of the items. The items used by August, however, may have been less likely to elicit spontaneous clustering strategies in ADHD children because of the effort involved in doing so.

The failure to find clustering differences between ADHD and NADHD children in the present study is intriguing. These results suggest that contrary to the suggestion of Douglas and others (August, 1987; Douglas, 1983), ADHD children can and do spontaneously use strategies to the same degree as NADHD children. In fact, the correlations between recall and clustering for ADHD children were all positive and in some cases

quite high (See Table 2). These findings suggest, at least for the ADHD children in this study, that the ADHD children's low levels of recall are not due to the children's failure to use strategies. The ADHD children in the present study are using an appropriate strategy, one of categorical clustering, for the items presented for recall.

It is puzzling, however, that NADHD children show a significant negative correlation between clustering and recall for the high-organization of words. Since this group exhibits higher levels of recall than ADHD children and higher levels of recall than NADHD children in the low-organization condition, one possible explanation is that the children are engaging in strategies other than clustering. If NADHD children are using strategies other than categorical clustering then clustering would be low but recall could still be high.

In the present study, the provision of category labels as cues at retrieval was not sufficient for the elimination of memory problems in ADHD children. ADHD children did improve their recall performance, however, when lists of items were categorically organized at

input and when cues were provided at retrieval. It would appear that factors other than those manipulated in the present study are contributing to the ADHD children's poor free- and cued-recall performance.

Results of studies conducted by Bjorklund and Harnishfeger (1987) on the development of resource capacity may be applicable to the present study. Bjorklund and Harnishfeger have found that limited strategy training leads to increases in clustering for both younger and older children, but that only the older children show corresponding increases in levels of recall. In fact, younger children show negative correlations between clustering and recall while older children show positive correlations between clustering and recall. Bjorklund and Harnishfeger suggest that younger children use their limited resource capacity for the implementation of strategies, therefore, they have fewer resources remaining for the storage and/or retrieval of items in memory.

The picture recall of ADHD children in the present study is similar to that of Bjorklund and Harnishfeger's younger children. ADHD and NADHD children showed comparable levels of clustering in both

the low- and high-organization conditions with both groups showing higher levels of clustering in the high-organization condition. The NADHD children in the high-organization condition also show higher levels of recall than NADHD children in the low-organization condition, whereas, the ADHD children in the high-organization condition do not have higher levels of recall than ADHD children in the low-organization condition. This is true for both free and cued recall. So, like the younger children in Bjorklund and Harnishfeger's study, ADHD children in the present study show higher levels of clustering of pictures but not correspondingly higher levels of recall of pictures. Unlike the younger children in that study, however, ADHD children do not show negative correlations between clustering and recall, but the correlation is quite low (r=.16).

These findings suggest that ADHD children may not make efficient use of their limited resource capacity. The implementation of more effortful strategies may deplete resources necessary for the storage and retrieval of information. Only one study of resource capacity in ADHD children has been conducted (Schachar

& Logan, 1990) and the authors were unable to conclude if their results were indicative of limited resource capacity in ADHD children.

In summary, the present study failed to support the position that ADHD children have retrieval deficits that contribute to their poor performance on memory tasks. It was clear that the ADHD children in this study were spontaneously using categorical clustering strategies. It is suggested that the study of the role of capacity limitations in ADHD children may provide valuable insight into the causes of ADHD children's poor memory performance.

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Table 1.

Means and F-Values for the Two Groups on Behavioral and Psychometric Measures

	ADHD Group (n=20)		NADHD Group (n=25)		
Measures	Mean	SD	Mean	SD	F
SEI	44.4	30.6	39.9	26.9	0.3
Verbal IQ	99.1	12.3	108.3	8.1	9.1+
Non-Verbal IQ	98.9	15.5	111.0	14.0	7.6+
Composite IQ	99.0	14.3	110.8	10.1	10.5+
Reading Score	101.7	13.6	112.8	11.6	8.8+
Mathematics Score	97.6	12.5	116.0	15.7	18.3+
Hyperactivity Score	75.3	7.9	55.4	0.9	158.1+
SNAP Checklist					
Pretty Much	7.1	3.3	.2	.4	105.8+
Very Much	6.2	5.5	.1	.4	30.7+

+$p<.05$

Table 2.

Correlations Between Free Recall and Clustering of Words and Pictures for ADHD and NADHD Children.

	ADHD Group	NADHD Group
Words		
Low Organization	.67+	-.08
High Organization	.61	-.76++
Pictures		
Low Organization	.52	.29
High Organization	.16	.37

++p<.01

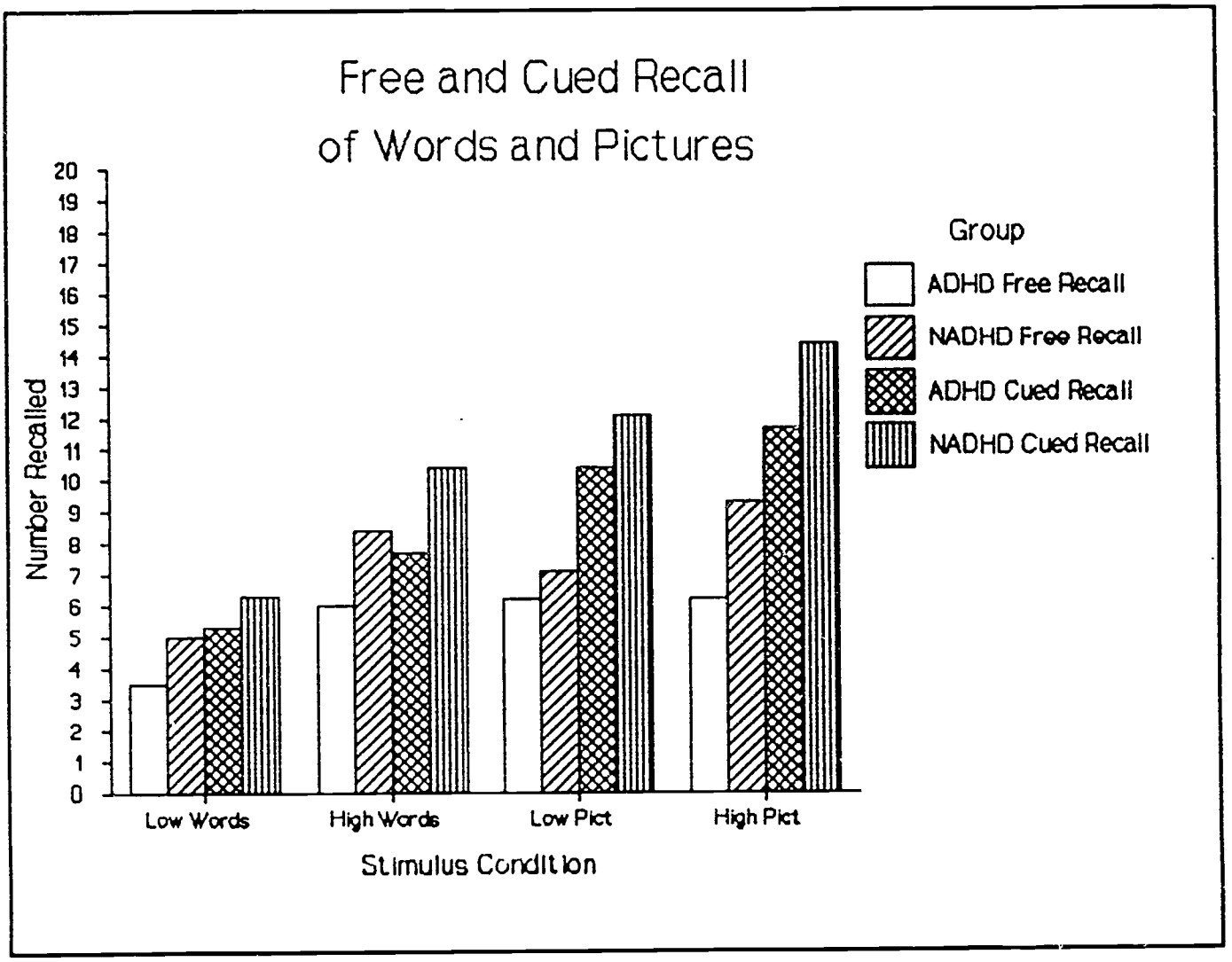
+p<.05

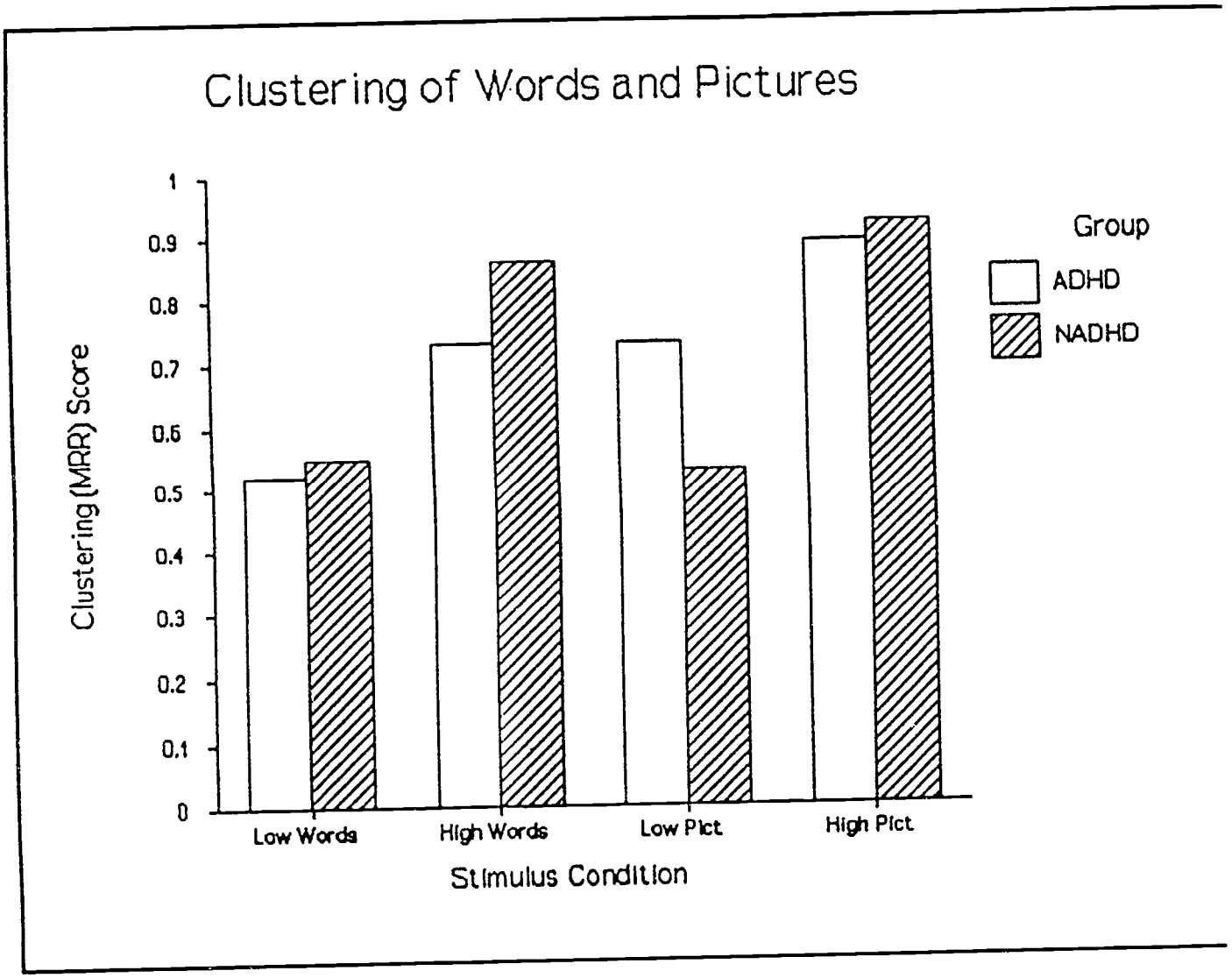
Figure Caption

Figure 1. Number of items recalled as a function of Group, Stimulus Condition, Organization, and Retrieval Condition.

Figure Caption

Figure 2. Clustering scores (MRR) as a function of Group, Stimulus Condition, Organization, and Retrieval Condition.


Free and Cued Recall
of Words and Pictures
Number Recalled
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Low Words
High Words
Low Pict
High Pict
Stimulus Condition
Group
ADHD Free Recall
NADHD Free Recall
ADHD Cued Recall
NADHD Cued Recall


Clustering of Words and Pictures
Clustering (MRR) Score
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Low Words
High Words
Low Pict
High Pict
Stimulus Condition
Group
ADHD
NADHD